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A MICROECONOMIC MODEL OF FARM DECISIONS IN AN LDC: A SIMULTANEOUS EQUATION APPROACH

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INTRODUCTION

It has long been recognized that agricultural development is crucial to overall economic development in the less developed countries (LDC's). However fostering rapid agricultural development is in itself a very complex problem. Heterogeneity at the farm level, and the interdependence of firm-household decisions are two elements contributing to this complexity.

Differences in farm size, farm type, soil type, resource endowments, and personal preferences are among the factors that enter into the decision-making process of each farm firm household. Government policies, infrastructure, and institutional constraints further change the environment in which these decisions are made. Furthermore, it has long been recognized that in the farm, the firm and household are not separate entities, that the decisions of one affect the other directly. This is particularly significant in LDC's, where small subsistence farmers orient their production towards the primary needs of family consumption. This leads to a diversified as distinct from a specialized pattern of production. Further, decisions to consume in cash or kind are also related to saving, borrowing, and investment decisions, since farmers can only generate cash income through marketable surpluses. But marketable surpluses depend on the consumption needs of the household, for farm produced products. Moreover, consumption also includes non-farm goods. The proportion of non-farm goods to total consumption expands with growing incomes as agricultural develop-

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ment occurs. This consumption requires a growing marketable surplus and directly affects the capacity to save and invest.

New investments are necessary for development. Therefore, a simultaneous increase in household consumption and farm investments appear to be competitive in the short-run. But in the long-run they become complementary, because current investment allows future income and hence future consumption to increase. Thus there is a trade-off between increased current savings and consumption as well as between current and future consumption.

In recent years economists have turned to both the theoretical and empirical problems involved, in integrating firm-household decisions. Theoretical attempts have included the works of Mellor [1969] and Nakajima [1969]. Empirical work has included the attempt on one hand to incorporate these related decisions in a l.p or r.l.p. framework [Singh, 1971 a; 1971 b; Mudahar, 1971; Day and Singh, 1973], and on the other hand to econometrically estimate partial models of firm behavior [Yotopolous and Lau, 1973]. The farm decisions are interdependent, dynamic and complex. These can only be properly understood when all of the interrelationships and feedback loops that exist between decisions and variables are considered simultaneously. This paper is devoted to such an effort.

METHODOLOGY

A Micro-Model of Farm Firm-Household Behavior

In this section a linear* microeconomic model of farm behavior in an LDC is developed. The model attempts to approximate the main features of firm-household decisions in a dynamic framework.

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* A linear or log linear form is emphasized for simplicity. Although a certain amount of statistical fit may have been compromised, it is the structure that is emphasized here.

As emphasized, farm behavior encompasses both firm and household decisions, but in keeping with the philosophy of the approach, these are not so identified. Instead all the behavioral equations relate to one entity - the farm - and the main economic activities and decisions it participates in. Six broad categories of farm decisions are investigated. These are the decisions to (1) produce farm outputs, (2) consume in kind and in cash, (3) sell surplus output in the markets, (4) use family and hired labor, (5) invest in fixed and quasi-fixed farm assets, and (6) borrow funds. These are discussed below.

1. The Production Decision

The production decision is central to farm behavior. It provides the income in both kind and cash and uses both owned and purchased inputs. This decision can be represented by the production function

$$Q = f \quad (L, K, N^F, N^H, O, t) \qquad (1)$$

where Q is the total value of gross farm product, L is the size of the operational holding, K is the stock of fixed capital on the farm, N^F the amount of family labor and N^H the amount of hired labor used in production and O the outlay on variable cash and non-cash inputs other than labor. This specification and the choice of explanatory variables is fairly common. A trend variable t is added to pick up the effects of technological and institutional changes [Brown, 1970] in the economy.

The outlay on variable agricultural inputs can be related in turn to the level of farm output Q, and the stock of capital in machinery and implements km. Further, since a large part of these inputs may be commercial inputs used to produce output atleast a part of which will be marketed, these outlays also depend upon the price index of agricultural inputs P^I, and agricultural outputs P^A. Moreover to the extent that farmers rely upon short

term borrowings to finance their production, these outlays also depend upon the level of borrowings B, the farm has access to. Thus we can specify the equation describing variable outlays as follows:

$$O = f \quad (Q, k_m, P^I, P^A, B) \qquad (2)$$

2. The Consumption Decision

The consumption decision is decomposed into two parts - subsistence consumption and cash consumption. Subsistence consumption refers to the consumption in kind out of farm output, and depends primarily on gross farm product Q. Additional factors affecting consumption in kind are lagged subsistence consumption C^S_{-1} due to "habit persistence" and the size of family F, measured in adult equivalents [Adams and Singh, 1972]. Further, we also note that consumption needs can also be satisfied through purchases so that outlays on current cash consumption C^C are likely to affect the amount of output retained for subsistence consumption needs. This dependence works both ways because farm produced and purchased goods are often poor substitutes in the consumption bundle and also because the ability to purchase consumer goods depends upon the size and mix of the marketed surplus which in turn depends upon the amounts of output retained for subsistence consumption.

The subsistence (or retained) consumption function can therefore, be expressed as:

$$C^S = f \quad (Q, F, C^C, C^S_{-1}) \ * \qquad (3)$$

With the growth of marketed surplus and market integration on the production side, there is an increase in the purchase of non-farm consumer

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* There is a possibility that Q and C^S_{-1} may be highly correlated in traditional subsistence economies where output is static. However, once agricultural transformation gets under way this is unlikely.

goods and market oriented consumption. The proportion of purchased to farm supplied consumption continuously increases with the growth of disposable farm incomes. Thus cash consumption C^C depends on disposable farm income Y^D, family size F, and subsistence consumption C^S. In addition it is likely to be adversely affected by a rise in consumer goods price index P^C.

Lagged cash consumption C^C_{-1} has also been included because it has been found to be a very reasonable and practical proxy for a number of theoritically advocated but empirically frustrating variables. The variables belonging to this category are, source of income, [Mizoguch, 1967]; [Kelley and Williamson, 1968], [Joshi, 1970], age composition of the household [Kelley and Williamson, 1968], [Leff, 1969], dependency ratio [Leff, 1969], age of the operator [Adams and Singh, 1972], presence of heirs [Adams and Singh, 1972], tastes and socio-psychological factors.

The cash consumption function can be expressed as

$$C^C = f\ (Y^D,\ F,\ C^S,\ P^C,\ C^C_{-1}) \qquad (4)$$

3. The Marketed Surplus

Farmers must sell a part of their produce in order to purchase non-farm production inputs, and consumer goods, pay off any financial obligations and to increase their on-farm investments. The marketed surplus function can also be viewed as a microeconomic supply function of agricultural goods in commodity markets. The amount of farm output sold M, is assumed to depend on the level of farm output O, the amount of farm output retained for subsistence C^S, the level of cash consumption C^C, and the price index of agricultural commodities P^A. The marketed surplus function can be written as:

$$M = f\ (O,\ C^S,\ C^C,\ P^A) \qquad (5)$$

4. Labor Use Decisions

Labor use is decomposed into two parts; the use of family labor, and

the use of hired labor. Family labor, a critical production input, is suplemented by hiring labor from outside. The demand for labor by the farm firm is highly seasonal in nature and this seasonality is further complicated by the fragmentation of the rural labor market in the LDC's.

The demand for family labor and demand for hired labor are interdependent. It is quite possible that the availability of cheap hired labor N^H, may encourage family members to increase their leisure time [Tyrchniewiez and Schuh, 1969]. On the other hand relatively high returns to family labor W^F, will encourage its use. The demand for family labor depends primarily on the level of gross farm product Q. The stock of capital in farm machinery km is used as a proxy variable for the level of farm mechanization since mechanization tends to depress the demand for labor.* The demand for family labor can, therefore, be expressed as

$$N^F = f\ (Q,\ km,\ W^A,\ W^F) \qquad (6)$$

The demand for hired labor has been considered to be determined mainly by wage rate of hired labor W^A, and price index of other agricultural inputs P^I, [Griliches, 1959, Schuh, 1962, Johnson and Heady, 1962, Schuh and Leeds, 1963, Helmers, 1965, Gisser, 1965, Wallace and Hoover, 1966, Tyrchniewicz and Schuh, 1966, 1969]. Further this demand also depends on the level of farm mechanization k_m on the amount of family labor used N^F, and on the index of agricultural commodity prices P^A [Tyrchniewica and Schuh, 1966 1969].

The demand for hired labor can be written as:

$$N^H = f\ (Q,\ k_m,\ W^A,\ P^I,\ P^A,\ N^F) \qquad (7)$$

The size of the operational holding has often been used as an explanatory variable in this regard [Wallace and Hoover, 1966]. The level of output

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* Johl [1971] found that selective and partial mechanization actually increases demand for labor.

Q, however is more appropriate. Output and size of holdings tend to vary proportionally when yields per acre are static. On the other hand when yields per acre increase rapidly labor demand increases proportionally with output and not with the size of holdings.

The unavailability of data prevents us from formulating a supply function for hired labor. Instead a wage rate function for hired labor is postulated as a market clearing mechanism. The agricultural wage rate for hired labor is assumed to be affected by the rate of unemployment U^R, consumer price index P^C, and lagged wage rate $W^A{}_{-1}$ [Pindyck, 1972], a formulation similar to the determinants of industrial wage rates. The landless rural labor force has a choice between agricultural and non-agricultural employment to some extent. Therefore, the industrial wage rate W^N, may affect also agricultural wages [Bagi, 1974 b].

The agricultural wage rate function is

$$W^A = f\ (U^R,\ P^C,\ W^N,\ W^A{}_{-1}) \qquad (8)$$

This wage rate function is not logical for a region where the individual farmers face unlimited supply of hired labor. But the situation in Punjab is different. The hired labor does not move between villages. They work for the farmers of their own village. A particular landless family works for a particular farm family only. It is more of a social contract than an economic one. Therefore, an individual farm family faces labor supply from a particular labor family, which usually has only one working male member. It should be added, however, that any farm laborer is free to have a non-farm job, if available. This is usually the case today.

5. The Investment Decision

In order to achieve higher levels of production in future the farmer must make additional investment now. He should also make provisions to replace the

depreciating capital stock at the farm. The investment decision, therefore, is an important and integral part of farm decisions.

In agricultural production, land is generally the most important, and limiting factor of production. This is especially true in highly populated developing countries. Land gains additional importance due to the scarcity of non-farm employment opportunities. It becomes a preferred investment in inflationary situations. Therefore, the farmers try to increase the size of their holdings. This leads us to hypothesize that investment is positively related to the size of the holding. A particular level of capital stock is required to operate a particular farm. It is, therefore, hypothesized that higher the level of lagged capital stock K_{-1} lower will be the current investment. Higher internal lagged savings S_{-1}, and credit availability B, will encourage investment. But high interest rate i, will have a discouraging effect on investment.

The investment decision can, therefore, be expressed by the following function:

$$I = f\ (L,\ K_{-1},\ i,\ S_{-1},\ B) \qquad (9)$$

6. Financial Decisions

The interaction of farm firm household with the financial markets remains to be explained. These integrally are tied up with the supply and demand for credit or loanable funds. In LDC's, it is assumed that the supply of new credit will have to come from government sources. This stems from a mistaken belief that there are insufficient internal funds with the agricultural sector although the predominant role of the informal sources of loanable funds like money lenders has been recognized. Commercial banks have been encouraged to participate in this process through the formal credit

market. This participation has been mandatory instead of a purely economic phenomenon. It is, therefore, not very meaningful or easy to develop micro supply functions for informal and formal institutional credit. We assume instead that the rate of interest serves as a reasonable instrument for clearing formal and informal financial markets in the rural sector.

The demand for credit depends on the rate of interest i [Nesser and Schuh, 1962], [Pani, 1966], [Chow, 1966]. We further assume that it depends on the variable costs of production O, current demand for on-farm investment I, and lagged internal savings S_{-1}. The variable costs of production O, may be very important explanatory variable because both formal and informal credit sources are quick to provide adequate funds for the purchase of agricultural inputs for the term of the production period. An individual considering an investment must explore possibilities of getting additional credits when he does not have enough funds of his own. The availability of savings should, therefore, reduce his demand for credit. We can then write the demand for credit as:

$$B = f\ (i,\ O,\ I,\ S_{-1}) \qquad (10)$$

Identities are helpful in making a simultaneous equations model "complete". Disposable income Y^D, savings S, and the capital stock on the farm K, are three such identities in this model. Disposable income is defined as:

$$Y^D = Q - C^S - O + Y^N - Tx - \delta K_{-1} \qquad (11)$$

where Q is the value of gross farm product, C^S subsistence consumption of farm produce, O is the variable costs of production, Y^N non-farm income to the family, Tr government tranfer payments, Tx the lump-sum taxes, and δK_{-1} is the depreciation of farm capital stock during the period.

Savings are residually defined as the difference between disposable income Y^D, and cash outlays on consumption C^C. We express savings as

$$S = Y^D - C^C \qquad (12)$$

The current stock of farm capital depends on the depreciated previous stock and addition gross investment:

$$K = (1 - \delta)\ K_{-1} + I \qquad (13)$$

The stock of capital at the end of the current period is equal to the lagged capital stock net of depreciation, plus new investments made during the current period.

Estimation Procedures

Formulation and estimation of an econometric model requires that two successive conditions; mathematical completeness, and identification must be met before actual estimation can take place. Mathematical completeness of this model requires that there must be as many linearly independent equations as endogenous variables. This model has 13 endogenous variables and 13 linearly independent equations. Therefore, it is mathematically complete. Furthermore, each and every behavioral equation of this model is over-identified. Therefore, this model can be estimated using any of the limited information or full information methods.

In order to take into account the heterogeneity at the farm level, time series of cross section data will have to be used. In that case variance components method [Maddala, 1971] or method suggested by Norlove (1971) should be used.

APPENDIX

Variable Definitions

C^S = Subsistence consumption (consumption of retained farm production)

C^C = Expenditure on cash consumption (= cash consumption)

Q = Gross farm production (in dollar terms)

F = Farm family size

C^S_{-1} = One period lagged consumption

Y^D = Disposable farm family income

P^C = price index of consumption goods

C^C_{-1} = One period lagged cash consumption

L = Area of land operated

K = Fixed capital (at the farm)

N^F = Demand for farm-family labor

N^H = Demand for hired labor

O = Variable costs of production

t = trend variable (e.g. 1960-1959, 1961-1959, 62-59, 63-59,...)

K_{-1} = Capital stock (fixed capital) one period lagged.

i = rate of interest

S_{-1} = savings (farm family savings) one period lagged

B = amount of borrowings

P^I = Price index of agricultural inputs (excluding labor)

P^A = Price index of agricultural (outputs) commodities

W^A = Agricultural wage rate

W^N = Non-agricultural wage rate

U^R = Rate of unemployment (preferably

I = Gross investment made during the current period

Y^N = Non-farm income to the farm family

W^F = Daily per family worker return from the farm.

Tx = Lump sum taxes e.g. land revenue, etc.

S = farm family savings during the current period

δ = rate of depreciation of capital stock

M = Market surplus of farm product

k_m = capital stock in machinery and implements on the farm

Variable Description

1. Endogenous Variables:

$$C^S,\ C^C,\ Q,\ I,\ O,\ N^H,\ N^F,\ W^A,\ B,\ Y^D,\ S,\ K,\ M$$

2. Predetermined Variables
   a) exogenous variables
      i) uncontrolled exogenous variables:

$$F,\ L,\ W^N,\ Y^N,\ \delta,\ U^R,\ P^C,\ k_m$$

      ii) controlled (policy) exogenous variables:

$$P^I,\ P^A,\ i,\ Tx$$

   b) lagged variables

      i) lagged endogenous variables;

$$C^S_{-1},\ C^C_{-1},\ K_{-1},\ S_{-1}$$

      ii) lagged exogenous - None

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